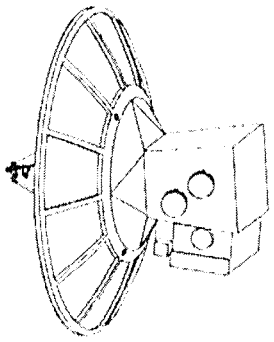

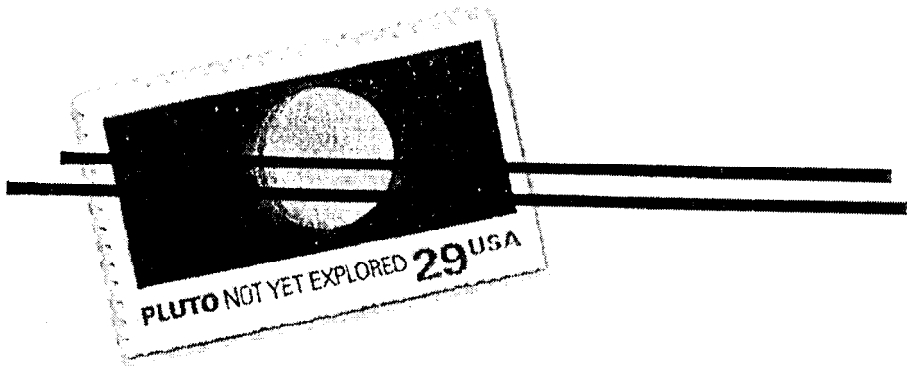

Critical Thinking & The Kinesthetic Connection

a whole body and mind approach to teaching science

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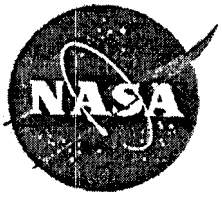

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ASSESSING YOUR OWN WORK

adapted by Jackie Giuliano from the Critical Thinking workshop material by Richard Paul

- Think about your thinking while you are thinking
- Think about your writing while you are writing

★ To continually improve your thinking arid writing, you must ask yourself questions:

☞ What precisely am I trying to accomplish?

☞ How can I determine whether or to what extent I am accomplishing my *goals?*

☞ What is the **precise** question I am trying to answer? What **exactly** must I do to settle this question or to develop, at least, a rationally defensible answer to it?

☞ What information do I need? How can I get this information? Do I have the requisite facts and/or experience to support one answer rather than another?

☞ Do I have to look at my subject from more than one point of view? Am I clear about the point of view within which I am reasoning?

☞ What am I taking for granted (assuming)? Am I justified in making these assumptions?

☞ Where is my reasoning going? What are the implications of what I have said?

☞ What concepts or ideas are prominent in my thinking? Do I need to re-think any of these ideas?

☞ How clear and precise are my uses of words? Am I saying what I mean? Am I meaning what I say? Am I saying more than I know? Do I really know what I have said?

☞ Am I addressing the question or issue at a superficial or a deep level? Is it necessary that I address it at **a** deeper **level?**

These are some of the most important questions to ask yourself. Taking them seriously is to take seriously the extent to which your thinking is clear, precise, accurate, well-grounded in empirical fact, well-reasoned, relevant, logical, consistent, wide (rather than narrow), and deep (rather than shallow). You will not absorb all these intellectual! standards overnight, but the sooner you begin, the farther you will get.

Critical Thinking

a whole body and mind approach to teaching science

by

Jack c Alan Giuliano

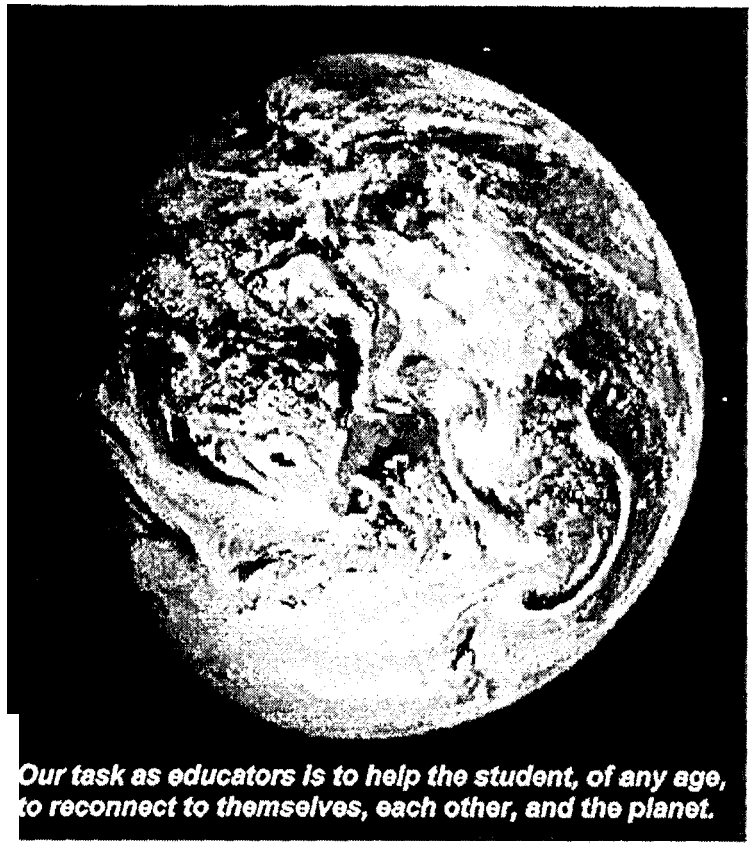
Teaching Students To Think and Reason

Educators of today face challenges unprecedered in the history of education. Overcrowded classrooms, inadequate facilities, and increased demands to move students through the system are but a few of the obstacles facing our teachers. Add to these burdens the fact that the world is changing rapidly, and the situation can seem overwhelming at best. Education began in the U.S. as a means to get farmers into factories, and standardized, mechanized, and linear modes of teaching became the norm. Today, however, there are very few farmers, few factory jobs, and the very reason why we educate is less clear and focused. But this confusion has forced a reevaluation of modes and methods and a powerful redirection is taking place, turning the classroom into a dynamic environment where students can be taught to embrace learning as a life-long process. To teach students in this manner is to teach thinking and reasoning skills. With this approach, the emphasis in the classroom becomes less on "facts and figures>' and more on understanding the underlying conceptual framework. It is an empowering way to teach because it validates the native intelligence that we all possess. This style is known as teaching students to "think critically."

It is an empowering way/0 teach because it validates the native intelligence that we all possess.

To fully embrace this new mode of teaching, wc must first become very aware of the obstacles that we face in the classroom. Most people have certain "myths" about what learning is that our western culture has reinforced in US. These myths are described beautifully by Ronald Gross in his excellent book Peak Learning (G .P. Putnam's Sons, 1991).

I earning certainly does not have to bc boring. It can be exciting and dynamic. The myth that learning is only done in school must be dispelled if wc are to make our students life-long learners. Learning takes place anywhere at any time. The myth that to learn we must bc passive and receptive and that wc "absorb" knowledge has been onc of the most damaging misconceptions of the learning process.



Our task as educators is to help the student, of any age, to reconnect to themselves, each other, and the planet.

Myths of Learning

- *Learning is boring*
- *Learning is only dorm in school*
- *We must be passive and receptive to "absorb" knowledge*
- *70 learn, you must put yourself under a teacher*
- *Learning must be systematic, logical, and planned*
- *Learning must be thorough or it's not worth doing*

Fears of Learning

- *I won't understand what I am [earning*
- *I am not a _ ___ ____ (math, science, etc.) kind of person*
- *I don 'i know how to learn this*
- *I won't remember what I am learning*
- *I feel ashamed that I don't know something*
- *There's too much to learn*

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Teaching Students to Think and Reason (continued)

Educational research clearly shows that we learn the best when we are actively involved in the process. "l'rue learning does not take place through absorption, but rather through dynamic action. The concept of what a teacher is needs "re-membering" in our students. A teacher should not be someone that you "put yourself under." Rather, a teacher should be someone you associate yourself with, someone who facilitates your journey through their abilities to relate their life experiences and knowledge to your life and experiences. The myth that learning must be systematic, logical, and planned has stifled much energy and made the learning process dry and lifeless. During the course of a class session, the teacher must be prepared to go wherever the needs of the class require, diverging from a lesson plan *where* necessary and creating an organic flow to the process. Finally, so many learners have been discouraged and damaged by the belief that unless you "know it all" about a subject, you may as well not have gotten any of it,

The drive to achieve "A's" on exams and the rewards associated with getting the "top grade" has created a whole series of "fears" about learning that wc as educators must heal. 'l'his approach is not suggesting that wc not encourage excellence. What it dots mean is that we owc our students an awareness of the reality that no one (that's right, no one) can know everything, about anything. Learning is dynamic and ever changing, and there is always more to learn about any subject.

When educational researchers talk about "proficiency" in a field, they arc not talking about 100°/0 knowledge of the subject, but 80%. It is so important for all of us to realize that wc must decide how much we need to know about a given subject and embark upon a learning program to achieve that knowledge. At the beginning of every class 1 teach, I tell the students that they arc "freed from the requirement to know everything about this subject. It is simply not possible anyway, so why not give yourselves permission, beginning right now, to realize that you do not have to know' it all to 'get it.'" It is amazing how such a simple, yet powerful acknowledgment of this reality relieves the student from unrealistic expectations and allows for excellence to appear.

"why not give yourselves permission, beginning right now, to realize that you do not have to know it all to 'get it.'"

Helping students to understand their myths and fears and to provide them with tools to overcome their obstacles to learning is the first important step in fostering the awareness that is required in order for them to think critically.

What is Teaching For Critical Thinking

The concept of teaching critical thinking can be summed up in two very important steps. First, you must teach students to notice that there is something to figure out. People are, in general, not good at reasoning, at noticing, and at judging when a problem is at hand that needs to bc solved. Next, once skill has been developed in noticing and appreciating the importance of problem solving, you help teach them how to figure it out.

A vital element of the process of teaching students the skills for reasoning involves letting go of the traditional view that learning is measured by the quantity of material covered. When teaching critical thinking skills, it is important to *cover less so **that the students learn more. No*** other concept is as revolutionary, critical or as much misunderstood as this one..

Studies done by the Center for Critical Thinking and Moral Critique at Sonoma State University in California show dramatically that students taught in this manner have a much better grasp of a subject, do much better on tests, and

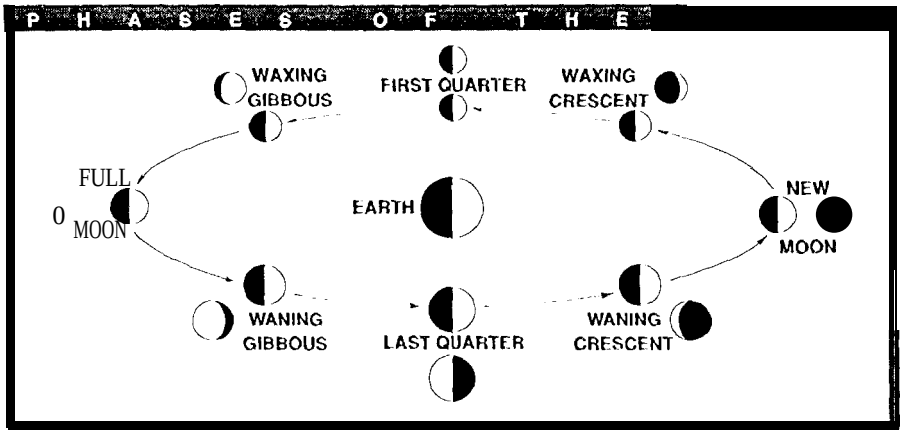
Cover Less So They Learn More

perform better in their chosen careers.

So, what dots it mean to cover less so that students learn more? In essence, it means that:

1. The teacher becomes a *facilitator,* not a lecturer, providing an environment where the students discover for themselves.
2. Teachers need to *remodel* their lesson plans, turning their lectures into interact ive experiences.
3. Students need to bc taught to effectively listen, write, and read critically and to learn to assess their work while they are doing it.

Evidence that "fact-based" teaching has minimal effectiveness can be seen if you look closely at how most students perceive the learning process. It is as if



Kinesthetic Teaching & Space Science Education

National Aeronautics & Space Administration

Jet Propulsion Laboratory
California Institute of Technology

By Richard Shope

Spring 1996

Kinesthetic refers to _movement_, the movement of the body as it senses its surroundings and responds to its urgings to discover and experience the world. _Kinesthetic learning_ refers to the process of learning by moving the body through the motions of direct _hands-on_ activities and by moving the body through minds-on representations of scientific theory. _Kinesthetic teaching_ focuses on instructional approaches that engage the body to integrate concepts, information, thoughts, feelings, and ideas into a coherent structure of knowledge.

Kinesthetic goes beyond calisthenics--more than mere activity, a kinesthetic approach engages the minds of students, getting, them up out of their seats, involving the whole body in a meaningful, related way. Carefully constructed kinesthetic instruction conveys conceptual content and inspires the intellect.

Kinesthetic strategies can be applied across the curriculum. initially, teaching efforts focused on language arts curriculum, demonstrating how mime could be used as an educational tool in the classroom to motivate students to write expressively, with picturesque detail and clear sequences of action. Along the way, this innovative approach attracted more attention and expanded its curricular possibilities, into areas of social studies, math, and science. Early on, it was clear that a kinesthetic approach was effective: students made immediate quantum leaps in their abilities to express themselves through writing, reading aloud and acting out the content in mime. Corresponding leaps in conceptual understanding among, students have been consistently observed by teachers in follow-up lessons.

Kinesthetic activity plays an important role in the construction of knowledge. Cognitive development is enhanced when a kinesthetic element of the teaching style is emphasized. Concepts and information are in effect *physically encoded* as lived experiences that can be drawn upon to enhance other aspects of learning. Kinesthetic teaching is compatible with a variety of pedagogical directions, such as: Piaget's developmental approach, Bloom's Educational Objectives, Renzulli's Schoolwide Enrichment Model, Gardner's Theory of Multiple Intelligences. Kinesthetic teaching fits within various curricular frameworks and can be applied to any curricular content--especially *science!*

What is the nature of the connection between kinesthetic teaching and science education?
The National Science Education Standards emphasizes going beyond hands-on to minds-on!
The kinesthetic approach is one way to get there!

Scientific theories are expressed as analogies. Analogy is where the worlds of art and science overlap. Mime is essentially an art form that communicates through the expression of physicalized analogies. The art of the mime can be extremely useful in science teaching: to *make tangible* the realm of abstract scientific theory. The structure of the movement art form can help construct analogies which enable teachers and students to understand what the theory is saying. Concepts produced by the scientist refer to realities we often cannot perceive directly, yet exist in ways we must account for. Concepts represented by the movement artist can illuminate these invisible realities. For students to understand the workings of complex motions, energy fields, objects on scales both subatomic and supergalactic, a kinesthetic approach engages the student actively, by creating physicalized analogies based on the scientific concept or theory under discussion.

The person who designs kinesthetic curriculum must grasp the scientific concept sufficiently to be aware of its rich nuances and relationships to other scientific ideas, as well the principles and possibilities of kinesthetic communication. By creating vignettes which demonstrate the workings of the theory, the structure becomes clear to those who participate in the sequence of kinesthetic curricular activities.

Since 1971, kinesthetic instructional strategies designed by Richard Shope have reached over a million schoolchildren and thousands of teachers in hundreds of schools throughout Southern California, Arizona, Colorado, Hawaii, Minnesota, and Mexico. The program has been utilized across the curriculum by programs devoted to gifted education, bilingual education, Chapter 1 enrichment, and recreation programs as well as the mainstream classroom. *

Curriculum support efforts of the Pluto Express Educational Outreach Program at NASA's Jet Propulsion Laboratory have focused on applying the kinesthetic approach to space science education. This has attracted great interest within NASA and within the National Science Teachers Association. In addition to kinesthetic activities, Pluto Educational Outreach has developed teacher enhancement workshops, demonstrating how kinesthetic teaching works, how to teach space science kinesthetically, and how teachers can add kinesthetic approaches to their array of teaching strategies. Workshop guides and curriculum support materials further enable science educators and teachers to design kinesthetic teaching strategies of their own.

Science teachers need the chance to experience a kinesthetic approach that promotes true conceptual understanding while also providing stimulation and enjoyment, able to illuminate text and bring the history and content of science to life. Pluto Educational Outreach brings together a unique combination of talents to meet this need and to enrich NASA's effort to provide innovative educational outreach directions.

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CREATING STRATEGIES FOR KINESTHETIC INSTRUCTION

We must address the creative energy of students by engaging both body and mind. By embedding science concepts in carefully crafted movement integrations-- not just hands-on, but *minds-on, lived body experiences-- we* can help students obtain an intuitive grasp of' difficult and abstract ideas.

Overview of the Principles of Kinesthetic Teaching Style

The kinesthetic connection physically encodes the essence of the content.

}Howard Gardner's *Theory of Multiple Intelligences.*

The Importance of Analogy in Scientific Theory

Cleating apt analogies is a key to communicating scientific theories.

Constructing Analogies In Motion

The art of mime offers a unique kinesthetic approach to engage students in thinking in analogies. To convey accurate content, a kinesthetic activity must be carefully constructed to carry the essence of the science information. Therefore, it is very important for the teacher to understand both the *science* and the *implications* of the analogies being used.

A Sample of Kinesthetic Activities Based on Space Science, Related to National Science Education Standards:

Archaeoastronomy: The Path of the Ancient Skywatchers

Interplanetary Distances: the Astronomical Unit

Pluto: **A New** Way to Explore the Planets!

Format ion of the Solar System: the Solar Nebular Theory

Building a Spacecraft: Team Effort

Orbital Mechanics: Falling Forwat d

Mars Explorat ion: From Launch to Lander

Sputnik to Explorer: The Space Race Begins

Telecom: Spacecraft Call Home!

Solar Wind Meets the Magnetosphere: Plasma, the Fourth State of Matter

Know the material by heart!

The first step is to become thoroughly immersed in the subject matter. 'l'his doesn't mean you have 10 know *everything.* But the person who designs the curriculum and the person who leads the activity must be aware of the concepts involved *and their implications.*

The whole point of a kinesthetic activity is to embed comprehensible content in such a way that the participant comes away with an intuitive feel for the concept involved.

Consider a seed: A seed is an undeveloped embryonic form that has its own structure *and* it contains the information within it that will ultimately allow it to reach its potential as a mature being.

A kinesthetic activity in this sense is like a seed, a structured exercise conceived to lead to a higher level learning experience. The kinesthetic activity is not the end, *but the beginning,* of the learning experience. The content is developed by involving participants in *lived body experiences.* As a lived experience, the content becomes both meaningful and memorable. By creating excitement about new ideas, the intent is to motivate the participant to seek out more knowledge!

Therefore, the person designing the curriculum and the person leading the activity must know the material by *heart* and be able to speak *from the heart.*

Create a masque that tells the story!

A *masque* is a short allegorical dramatic performance presented by masked characters, often with mime and music. A kinesthetic learning activity carries the content in the structure of a masque-- a marvelous synthesis of knowledge and excitement.

We are always in the middle of the story. Wherever we choose to begin, something has always been said before, and wherever we choose to leave off, something more is left to say. Information regarded as true today may be outdated very shortly! Knowledge evolves at a rapid pace.

A decision must be made with regard to the likely body of knowledge of the participants. In a given subject area, the curriculum developer must consider the most likely level of *lived body experience* of the audience-- including teachers, students at various levels, parents, and the community. If the kinesthetic activity is to be effective, it must neither be so simple as to be uninteresting nor so difficult as to become inaccessible.

Then a sequence must be considered that will lead from that point of general knowledge to the import of the new concepts in such a way that the activity makes further study of the subject more likely and more comprehensible. When the students participate kinesthetically, they engage themselves wholeheartedly in a *minds-on* activity. Structured properly the kinesthetic connection stimulates students to make a *quantum leap!*

Richard Shape

they put a bucket on their heads at the beginning of the term. The teacher keeps filling, the bucket with facts and ideas and the bucket gets heavier and heavier. The student is staggering around, dreading, coming to class and is painfully memorizing the material. Then, finally, the exam comes, the bucket is quickly crept ied, and st udents can be heard saying "thank goodness 1 don't have to know that stuff anymore." There can be few forms of failure of the teaching process more dramatic than this phenomenon. 1 lowever, students who are taught by facilitators who are involving them in the learning process, consider the knowledge gained to be a permanent part of their lives.

Remodeling a lesson plan can be a very valuable experience for the teacher. Take a look at your lecture and ask yourself: What three or four fundamental and powerful concepts do you want to convey to the students? Then, develop activities for the students to discover those ideas for themselves. There are many resources available to help in this process. The Center for Critical Thinking at Sonoma State University has excellent in-service programs and holdan outstanding conference each year. 1 have presented workshops at these conferences.

Tools For Better learning

If the principle of *cover less so that they learn more* is to be practiced, then students need to be given enhanced skills in listening, reading, and writing. Listening is the first skill that must be enhanced. The notion that listening is a passive activity needs to be dispelled. Ask your students regularly to restate, in their own words, what either you or another student has just said. Conduct a imple exercise in listening,. Have stuents pair up and take turns speaking to ach other about something they are interested in right now. The listener is intructed to not speak or respond in any vay. Have everyone discuss how it felt o listen without responding, and speaking without acknowledgment. People will soon realize that they have often responded in a discussion without fully listening. Most of us begin formulating the esponse in a discussion long before the speaker has finished. This practice takes us totally out of the moment and we cannot respond well if we haven't listened well.

Students who are taught by facilitators who are involving them in the learning process consider the knowledge gained to be a permanent part of their lives.

Students need to be taught how to read critically as well. Most of us have been taught to read by reading, one word at a time and expecting and hoping that the meaning of what we read will accumulate. This has been found to be a very inefficient means of learning. Methods exist that enable the reader to see the whole represented by the book by taking in more than one word at a time. An outstanding program that can transform the learning process is the Evelyn Wood Reading Dynamics Program. In addition to increasing one's reading speed, the program provides tools that totally transform the learning process. An excellent paperback book by Stanley Frank called the ***Evelyn Wood 7-Day Reading Dynamics Program*** describes the entire process.

Time should be spent discussing the writing process, paying special attention to methods for researching, outlining, creating drafts, and assessing one's own work while they are writing.

A virtually untapped resource in opening up the learning process is the use of the creative arts as tools to explore and open the mind and heart. Our odies and minds are capable of perceiving a wealth of feelings, sensations, and nages which, if tapped, can dramatically enhance the learning process.

The Creative Arts As Powerful Tools

The field of art therapy is an important illustration of the power of creative xpression. Through various forms of rt, deep feelings can be tapped and locks can be softened. Much healing as taken place in emotionally disturbed ndividuals through the usc of art I have sed various forms of art therapy with ny students to help open them up for a earning activity as well as to allow processing of some of the disturbing information I will often share during my environmental science classes. 1 try to have a qualified art therapist on hand to conduct these activities, but there are art activities that can be used with minimal risk. The power of art is great, and a teacher should always be aware that such creative expression can bring up deep feelings. The Pluto Express Educational Outreach Program has worked with art therapist Lynne Okun to develop a number of art projects that can be used with students prior to beginning a learning activity. These activities put the students in a very receptive state and the learning experience becomes much more rich and full.

Involving The Body

learning activities that involve body movement also enhance the learning process. A learning experience that is "lived" in the body is one that is remembered for a lifetime. Richard Shope of the Pluto Express Preproject at NASA's Jet Propulsion Laboratory has developed many new and innovative *kinesthetic* activities that teach science and other disciplines through body movement.

Educational Outreach

Pluto Express has made significant strides toward making space exploration more accessible to everyone. The Pluto Express EducationalOutr each program has developed a series of curriculum guides containing innovative exercises to enhance educators' efforts to teach space science to students of all ages.

These research-based teaching strategies encourage both *critical thinking* and *kinesthetic* approaches, engaging body and mind in ways that allow students to *live* the learning experience. These minds-on activities develop an intuitive grasp of space science concepts and encourage an attitude of life-long learning.

Until one is committed, there is hesitancy, the chance to draw back, always ineffectiveness. Concerning all acts of initiative (and creation), there is one elementary truth, the ignorance of which kills countless ideas and splendid plans: that the moment one definitely commits oneself, then providence moves too.

All sorts of things occur to help one that would never otherwise have occurred. A whole stream of events issues from the decision, raising in one's favor all manner of unforeseen incidents and meetings and material assistance, which no [one] could have dreamed would have come [their] way.

Whatever you do, or dream you can, begin it.
Boldness has genius, power and magic in it.

Begin it now.

—Goethe

A TEMPLATE FOR DESIGNING A KINESTHETIC LESSON

A Quantum Approach to Increase the Probability of Learning

EDUCATIONAL OBJECTIVES
At-A-Glance

1 To THINK CRITICALLY about
2 To THINK CREATIVELY about
3 To IDENTIFY examples of
4 To STATE the basic principles involved "in.
5 To DEFINE: .) *arm' other important terms.*
6 To DESCRIBE the processes involved in exploring
7 To GET INVOLVED!

BACKGROUND DISCUSSION RELATED TO SUBJECT MATTER
(Drawing from the knowledge base that the teacher should be comfortable with)

The idea is to allow students to experience the dynamics of a scientific theory in context of classroom learning. By experiencing a kinesthetic demonstration, these difficult and abstract concepts become more accessible. Then students feel on more solid ground when they choose to pick up a book, read an article, or otherwise look further into the subject at hand.

Personification is a literary figure of speech in which a non-human objector creature is referred to *as if* it were a person. To say something like, *the sun smiled down upon us, is* a personification. The sun is not really a person smiling, yet the image conveys a sense of how we relate to the sun. The very names of the planets are personifications. A kinesthetic activity relies on personification as a way to convey analogies, to help make abstract theories more intuitive.

KEY QUESTIONS FOR DISCUSSION
(Eliciting several questions to get everybody thinking, about the subject)

COMMENTARY
(Going into More Depth, learning Together, Exploring various Texts & other Sour-cm)

THE KINESTHETIC CONNECTION
(Using a movement form such as mime to create a *minds-on* activity that gets students up out of their seats)

Drawing from the core of the educational objectives related to the subject matter, devise a whole body movement activity that allows the student to personify the various aspects of the content to be learned. lead a small group initially as an example, then devise a structure that allows various small groups to try out the activity, creating on their own. This is a good time to circulate among the groups to assess the quality of interaction, including discussion of the topic, original approaches to the task, assisting students where needed, allowing time for the ideas to develop. **When** the moment is right, pull everyone together to share the work.

Each vignette represents a *minds-on* experiment, and while they can be developed into performances, the main focus here is to draw from the student work to reflect upon and develop content *understanding.* The student presentations allow an immediate *assessment process.* If the *teacher* has been participant ing fully, by maintaining an awareness of the different processes that have been going on simultaneously, the content of the presentations reflects what the students learned *existentially, at that moment.* The teacher, then, has the opportunity to seize the moment to lead students into the next learning adventure related to the *quantum leaps* perceived during the kinesthetic presentations!

VARIATIONS

Inevitably, kinesthetic activities trigger the invention of new variations on a theme, as students and teachers alike discover new ways of applying the basic principle of integrating content through movement expression.

FROM THE OUTER PLANETS TO THE INNER CITY TEACHING THE RELEVANCE OF SPACE SCIENCE

The Pluto Express Educational Outreach Office is designing programs to reach inner city youth in Greater Los Angeles, as an example of what might be done in other large urban areas. To reach these young people, the content of the field of space science is broken down into five major areas. Kinesthetic activities are devised to inspire immediate interest and awareness of future opportunity, From this starting point, diverse directions are pursued as students define new pathways and gain a sense of the universal human interest in the meaning of the events of the sky.

History of Astronomy and Space Science: Historical developments within the field of astronomy leading into the Space Age.

Modern Astronomy and the Space Age: From Kepler to the current times of looking toward the beginnings of the universe, his would include the mainstream Western tradition of the advance of ideas about our place in the universe since the paradigm shift that placed the Earth in motion around the sun, to our current exploration of space.

Archaeoastronomy and Astronomy Traditions: Ancient skywatchers from every civilization kept detailed records of the movements of the planets and stars, named constellations, created calendars, built observatories, all looking with just the naked eye. By following the pathway of the ancient skywatchers, students gain a sense of the sweep of science through the ages and see how ideas evolved, often connecting with vital strands of cultural heritage.

Cosmology: World views related to astronomy concepts; implications of the night sky from different cultural viewpoints. Even today, different living traditions are contributing to our overall understanding of the universe, enhancing an appreciation of the achievements in the fields of astronomy and space science.

Principles of Astrophysics: Basic physics principles that are needed to understand space science.

The Nature of Light: Inferences we make from what we see, the speed of light, the wave-particle discussion, the behavior of light traveling through space.

The Electromagnetic Spectrum: From gamma rays to radio waves.

The Laws of Motion: Basics of Kepler's Laws, how the solar system moves.

Gravity: From Newton to Einstein, how we understand gravity, to the latest notions.

Matter & Energy: Basic principles of how matter and energy interact.

Principles of Astronomy: Basic elements of the field of Astronomy.

Interpreting what we observe through various instruments:

Naked Eye: Just looking, learning your way around the night sky

Binoculars: Wide field looking for urban skies

Telescopes: Visible light

Radio Astronomy: How we get information from radio waves

Spectroscopy: Interpreting chemical information from the light we see from planets and stars.

Classifying what we see: The horizon reference system, types of planets, moons, comets, stars, and other objects.

Origin and evolution of the universe: Stellar evolution, formation of the solar system.

Space Flight: Science and technology of the age of Space Exploration.

Rocketry: From Newton's cannonball analogy to the multi-stage rocket; propulsion, escape velocity,

Orbital Mechanics: How we use the laws of motion to navigate to destinations beyond Earth's orbit.

Communicating with Spacecraft: The marvels of telecommunications.

From Spacecraft to Sciencecraft: The art and science of designing spacecraft, science instruments, devising experiments to learn about atmospheres, surfaces, and chemistry of planetary bodies in the solar system.

Exploration of Space: Human and telerobotic missions, reaching the Moon, voyaging on the Space Shuttle, living on the space station, telerobotic scouts, sample returns, on to Mars and *beyond!*

Earth From Space: Reflections on our relationship to the Earth, its planetary neighborhood and beyond.

Earth as a System: Implications of the Earth in its zone within the solar system.

Comparing Earth to Other Planets: How do we understand planets, moons, asteroids, comets, Kuiper objects and other Solar System phenomena in relationship to the Earth?

Global Ecology: How seeing Earth from space helps us understand our environment.

Our Place in the Universe: Musing on our own significance, finding other planetary systems.

Searching for Life: Is there life on other worlds? Probabilities? Risk factors?

EXAMPLE OF REMODELED LESSON PLAN - I

TOPIC: Fighting for Peace and Justice

Class **#8** from *SCI/SOC* 312 *Environments/Action and Social Responsibility*

- Instead of the lecture 1 had planned:

☞ Fundamental Question at Hand:

1. Why is it a "fight" to attain world peace?

☞ Fundamental Concepts, Insights, Understandings, and Knowledge

1. Achieving "world peace" means different things to different people
2. When you consider the social, economic, political, and personal points of view, there are many artificial barriers to world peace
3. Not everyone may want world peace.
4. World peace can only be obtained through the attitudes of people, not laws, technology or other superficialities -it is US.
5. To take the student out of their own ego-centered world and think on a broader scale.
6. To demonstrate the importance of the individual's views and actions.

EXAMPLE OF REMODELED LESSON PLAN -II

The Process

1. Socratic questioning of the text

- ☞ What is the point of the paragraph
- ☞ what do you think about it
- ☞ what do you think about her interpretation

2. Count off 4 or 5 groups, depending on how many are in class

Assign roles in group:

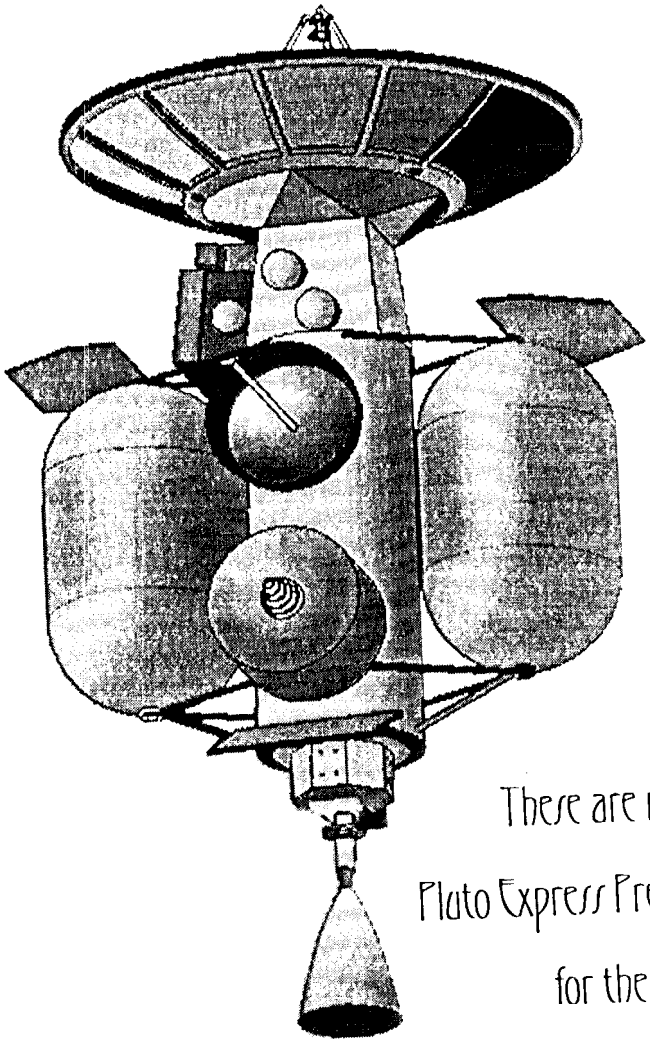
- ☞ no one speaks until called upon
- ☞ group facilitator duties(does not participate, moderates)
- ☞ recorder: takes the notes

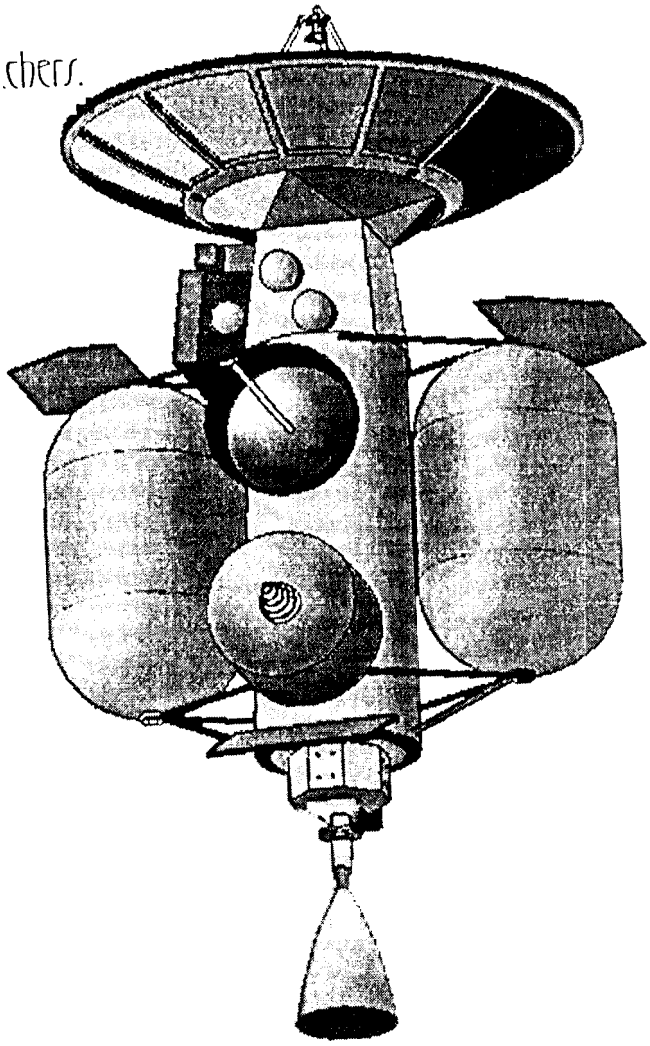
3. The task: ***From your assigned point of view, come up with a plan for world peace.***

4. The product: a group report, based on consensus. Dissenting opinions are aHowed. Give 30 minutes for group to develop their report.

5. ASSIGNMENT: Write a couple of paragraphs on what you learned from this exercise.

Since it was discovered in 1930 by Clyde Tombaugh,
The Planet Pluto has fascinated 20th Century chers.





These are recent design possibilities produced by the
Pluto Express Preproject Team at the Jet Propulsion Laboratory,
for the Two Sciencecraft that will be launched
early in the 21st Century
to explore the Planet Pluto, its moon Charon,
and possibly the Kuiper obj c out beyond